

Conference Report

ELECTRONIC DOSIMETRY WORKSHOP Gaithersburg, MD October 14-16, 1998

Report prepared by

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1. Introduction

Maintaining an accurate record of worker doses in facilities where workers could be exposed to ionizing radiation is a primary concern of most health physicists. Dosimetry records are needed to assist in controlling the radiation exposure of workers and to show that dose limits are not exceeded. Both from a practical standpoint and from a legal standpoint, health physicists are

forced into using systems with proven reliability and documented performance as their primary dosimetry. Primary dosimetry (dose of record) in the United States is currently maintained using passive dosimeters such as film or thermoluminescent dosimeter (TLD) materials.

Electronic dosimeters (ED) have been used for secondary dosimetry to monitor radiation exposure in the workplace for several years. The potential advantages of these active, more complex devices have long been recognized [1], [2], and [3]. Because of their ability to supply incremental readings instantaneously to the user and supervisory health physicists and their integration into telemetry and video monitored access control systems, they have become a key part of some radiation protection programs. With recent improvements in their reliability and capability, coupled with their superior precision and lower detection limits for some types of radiation, electronic dosimeters are now being considered for dose of record. The ED still has limitations such as susceptibility to radio-frequency radiation, energy dependence, and angular dependence. One indication that health physicists remain interested in their application for primary dosimetry lies in the fact that there are approximately 15 manufacturers of EDs in the U.S. market alone—possibly more in Japan, Russia, Europe, etc.

The timeliness of this first ED workshop was evidenced when over 80 participants from around the world gathered in Gaithersburg, MD, for 2 1/2 days in October 1997. The focus of the workshop was to define the conditions under which the ED could be used for primary dosimetry in the near term and to discuss the steps needed to gain general acceptance of the ED for primary dosimetry. The Nuclear Regulatory Commission (NRC), the National Institute of Standards and Technology, and the Council on Ionizing Radiation Measurements and Standards (CIRMS) cosponsored the workshop.

A significant limitation to this new technology is the lack of a mechanism for dissemination of results of the laboratory and field testing that has been performed to date. Published works are extremely limited for two main reasons. First, most testing has been performed at nuclear power plants where, at most, internal reports are generated which have limited public access. Second, this is a rapidly changing field. By the time a peer-reviewed article could be published, it would be too late to be meaningful. Although regular meetings provide a forum for topics in such areas as solid-state dosimetry, neutron dosimetry, etc., such a forum has not been established for electronic dosimetry. As a consequence, general acceptance for use in primary dosimetry is slow in coming. One of the features of this workshop was that it offered common grounds on which regulators, manufacturers and users could meet and discuss results, issues, needs and concerns.

2. Invited and Contributed Talks

The first day began with an opening address from Dr. John Gill of Great Britain's Health and Safety Executive (HSE). He discussed the HSE's interests in personal dosimetry for ionizing radiation and, in particular, its approval process for dosimetry of record and their experience with approval of a dosimetry service using electronic dosimeters. The fact that requirements for dosimetry service approval apply equally to electronic or passive type services was stressed. His talk indicated a number of matters of particular importance during the assessment of the ED service.

In a later talk, Andy Weeks spoke of Magnox Electric's plans to seek approval for a second service that would provide ED dosimetry for workers at their nuclear power stations in Great Britain. Field evaluation of an ED during a refueling outage at Sizewell B Power Station indicated that ED performance was acceptable for both control and record dosimetry. With over 60 000 uses of the ED during entries into radiologically controlled areas, there were only 113 reported ED faults. Several of the faults were detected while the units were still in the storage rack; no fault resulted in a significant operational problem. Plans to consider the electronic dosimeter for record dosimetry at other facilities in the United States and Europe were also presented. Several observations on electronic dosimeter performance limitations, developments in effective dose equivalent considerations, total uncertainty and neutron dosimetry were also presented and discussed.

One of the most extensive ED evaluation programs in North America was carried out by Ontario Hydro in 1994-95 [4][5]. (By the time Ref. [5] went to press, it was already noted in an appendix that many of the

problems discussed in the paper had been rectified through design changes.) The Ontario-Hydro project team concluded that the TLD should continue as the primary dosimeter and that all stations should use an ED as a secondary dosimeter [6] [7]. Ross Hirning explained that one problem in the past had been that each station chose a different model of ED. Since 1995, the different stations use the same model for consistency and better evaluation. He presented the lessons learned and identified some of the problems that were encountered. Testing continues at Ontario Hydro, but the ED will not become the only dosimeter for the foreseeable future.

Since 1994, Washington Public Power Supply System has routinely issued EDs along with the primary TLDs to workers entering specified areas according to Lyle Rathbun. Results of the two types of dosimetry are compared three to four times a year and on an annual basis. The overall ratio of electronic dosimeter results to TLD results was 1.01 in 1996 and 0.99 for available data in 1997. Individual differences were less than 10 % for doses above 100 mrem. D. S. Gregory from the Westinghouse Savannah River Co. presented information on the performance of one ED model for low-energy photons (≈ 17 keV). In the test geometries there was a significant underresponse. Investigations are continuing and improvements in performance are expected.

Several talks were given by commercial manufacturers in which they presented their latest improvements in design and functionality. One ED model now under evaluation will be able to transmit data automatically when interrogated by a reader station. Present models require that the user insert the device into a reader. In general, the ED is becoming smaller, smarter and more reliable. Quality control in the manufacturing process was also discussed.

A paper was presented that covered several issues regarding the performance and use of electronic dosimeters. This included several problems observed for one or more models of electronic dosimeters; a version of this paper has been published [8]. The author noted several limitations such as poor energy response, poor reliability, anomalous readings caused by environmental interferences (radio frequency interference, magnetic fields, etc.) and problems with the internal programs. Several limitations in terms of dose rate response and alarms (e.g., audibility) were also observed. Some of the observations represent basic limitations of the technology (e.g., energy response) and some have been resolved (e.g., program problems). However, it is important that users and manufacturers are aware of such limitations so that designs can be improved or such limitations can be accounted for during use in the field.

Jerre Forbes of American Nuclear Insurers spoke of the legal liability and the need to use two independent dosimeters for the purposes of back up and corroboration of personal doses. However, this seems to be unique to the U. S. nuclear power industry. Jerre recommended the use of approved (accredited) dosimetry systems which is the accepted approach in many countries.

The current status of ANSI N13.27, Performance requirements for pocket-sized alarm dosimeters and alarm ratemeters, which is currently under revision, was discussed. This standard, along with ANSI N 42.20, will provide guidance on electronic and radiation performance requirements for the ED. The presentation included a comparison of requirements between national and international standards. The status of five international standards (International Electrotechnical Commission, IEC) for electronic dosimetry were presented. All are either in the final stages of development or published.

A representative from the National Voluntary Laboratory Accreditation Program (NVLAP) spoke of their experiences in proficiency testing of the EDs to ANSI N13.11, personnel dosimetry performance test criteria. Although testing is required for passive dosimetry, all testing is voluntary for electronic dosimeters. Most testing to date has been in Category IV—high-energy photons (^{137}Cs and/or ^{60}Co). The EDs compare favorably with the TLDs in this category, but not enough data has accumulated in the other categories to permit useful conclusions. One finding of note is that the EDs exhibit a much lower standard deviation in their responses than either TLD or film badges.

3. Breakout Sessions

On the second day of the meeting the participants were divided into four working groups to discuss the various elements of the use of the ED for dose of record. Topics for the break-out sessions were as follows:

ED performance requirements

Role of standards

Third party overview of programs

User performance control activities

Calibration issues and accreditation

User procedures and documentation

Reconstruction of dose for ED users

Use of the ED for primary dosimetry today

Developments needed in electronic dosimetry

Use of the ED for record dosimetry

Each group discussed as many of the different topics as possible during the course of the day. As one would expect, notes from each of the groups show that a diversity of opinions exist on several of the issues; the items discussed and depth of discussion varied from group to group. Some of the points that can be taken from the discussions of the work groups are noted below:

- Type testing of EDs should become more structured. A method needs to be developed to accredit or approve laboratories for testing. Reporting of test results should be based on quantitative performance results (not pass or fail) and should be provided in a uniform format available to a broad audience. It was also felt that this testing should be the responsibility of the manufacturers.
- The accreditation or approval of primary dosimetry is felt to be an important step and regulations should be modified to include the ED in this process. Several attendees requested that NRC provide a formal position statement regarding approval and use of the ED.
- Improvements in the ED are needed in terms of response to weakly penetrating radiations (x ray, beta), neutrons, and high dose rates. As noted by some of the working groups, the need for these capabilities will be specific to the application. Improved immunity to radio frequency interference is also needed. Interestingly, several attendees were interested in an inexpensive ED that simply measured dose without all of the warning functions.
- There is still confusion in terms of standards that may apply to the ED. Most users are not aware of the content of existing standards (ANSI N42.20 and the IEC standards) and the new ANSI N13.27 revision has not been widely distributed. A greater awareness of applicable standards and their benefits and limitations is needed by the users.
- Most of the groups felt that further investigations were not required when dosimetry results compared within 25 % above 100 mrem.

4. Summary Discussion

The final half-day session consisted of an open discussion among the various work groups, a search for consensus among recommendations, and was intended to result in a listing of the steps forward in the broad acceptance of the ED for dose of record. The discussion supported the points noted above for the working groups. Due to the time available and the diversity of opinions, it was not possible to list specific steps leading to the broad acceptance of the ED for dose of record applications.

The discussion was dominated by the need to ensure that the ED is measured by the same standards as the passive dosimeters currently in use. This focused on defining the ED as a processed dosimeter in order to confirm that it fit the requirements of 10CFR20 for processed dosimeters. It is clear that a process is used by the ED to change from radiation energy deposited in the detector to a dose quantity representing risk to the worker. However, this process is established by the manufacturer of the ED and in a sense represents “a contracted service” in the context of passive (TLD or film) dosimeters. Thus, it appears that the manufacturer should hold the accreditation. Unfortunately, this leaves questions concerning the user’s program quality since he will not be involved in the accreditation. The user has an important role in routine testing and/or calibration of the EDs and this may be the point at which quality control activities (accreditation) should be addressed. Although a consensus was not reached, methods of gaining the required recognition were discussed such as changing regulations to include electronic dosimeters or changing the definition of processing to include electronic dosimeters.

During the final discussion, it appeared that soliciting a change in the regulations would permit inclusion of the ED in the present dosimetry accreditation (NVLAP) program. However, it was pointed out by an NRC representative that such a process would be lengthy and would have a low chance of success, but that a change in the individual license might be a quicker means of incorporating the ED into dosimetry programs.

5. Conclusions

In such a rapidly changing field, open communication and dialogue at the earliest stages will assist in the development of technologies that will meet the needs of the greatest number of users and remain cost effective. Attendees felt that the workshop was timely and valuable and hoped that additional workshops would be held in the future. However, several felt that a future workshop should occur after the NRC had developed a position on the use of the ED.

Information on the presentations and breakout sessions is being assembled for incorporation into proceedings that will be published in the near future. Two documents have gone to press since the workshop: EPRI-107994, “EDE implementation: electronic dosimetry angular response,” and NUREG/CR-6581, “Considerations in the application of the electronic dosimeter to dose of record.” Also, the ANSI N13.27 draft has received approval (with comments) from the Health Physics Society. The standard will need approval of the N13 committee before it becomes an official U.S. standard.

6. References

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